

COMPREHENSIVE QUALITY ASSURANCE PLAN

NOVEMBER 15, 1991

**SOUTH FLORIDA
WATER MANAGEMENT DISTRICT**

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Comprehensive Quality Assurance Plan

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for

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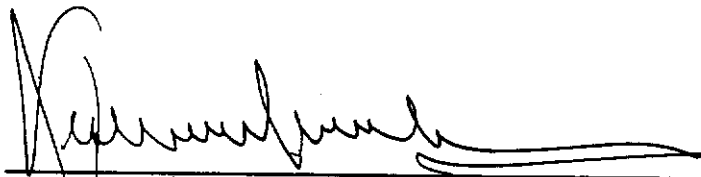
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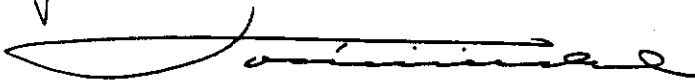
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1-14-92
Date

APPROVED

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3.0 STATEMENT OF POLICY

This is a comprehensive quality assurance plan (CQAP) for the sampling and analytical programs of the South Florida Water Management District (SFWMD). These programs encompass surface, estuarine, ground water and sediment monitoring programs. The Chemistry Laboratory Division is certified by the Florida Department of Health and Rehabilitative Services as an environmental laboratory capable of performing the metals, nutrients, and general parameter 1 & 2 categories.

This CQAP is intended to be used as a reference and guide for those personnel collecting and analyzing samples and evaluating the results obtained for those analyses. It sets forth the minimum standards to be complied with for these activities and provides a reference for evaluating the procedures used during the time this CQAP is in effect.

The SFWMD is committed to the use of good QA/QC management practices to produce data of a verifiable quality.

Staff Environmental Scientist, Environmental Sciences Division, ES Quality Assurance Officer: Responsible for coordination of all project quality assurance plans for the Environmental Sciences Division, review of quality control results for the projects, training of division personnel in quality control procedures. The role of QA officer is separate and distinct from all other responsibilities for any specific project.

Staff Environmental Scientist, Water Quality Division, WQ Quality Assurance Officer: Responsible for coordination of all project quality assurance plans for the Water Quality Division, review of quality control results for the projects, training of division personnel in quality control procedures. The role of QA officer is separate and distinct from all other responsibilities for any specific project.

Staff Hydrogeologist, Hydrogeology Division, HG Quality Assurance Officer: Responsible for coordination of all project quality assurance plans for the Hydrogeology Division, review of quality control results for the projects, training of division personnel in quality control procedures. The role of QA officer is separate and distinct from all other responsibilities for any specific project.

Supervising Professional-Environmentalists and Hydrogeologists: Responsible for the supervision of the project managers and field operations supervisors, training of personnel, coordination with divisional QA officers for QA/QC issues, development of sampling networks, review of quality control data and analytical results, and development of research projects.

Supervising Professional-Field Office, Water Quality Division: Responsible for supervision of the Water Quality Division's Okeechobee office, training of personnel in sampling and quality control procedures, design of sampling networks and research projects, review of quality control data and analytical results, and coordination with divisional QA officer.

Field Operations Supervisor, Hydrogeology Division: Responsible for the allocation of personnel for groundwater sampling, drilling and logging of monitor wells, and training of personnel.

Field Operations Supervisor, Water Quality Division: Responsible for the allocation of personnel and equipment for surface water sampling, training of personnel in sampling and quality control procedures, review of quality control data, review of analytical results for specified projects.

Programmer Analyst, Chemistry Laboratory Division: Responsible for the maintenance and integrity of the laboratory information management system, supervision of the data entry personnel, programming computers, testing software packages, and the operation of the LIMS.

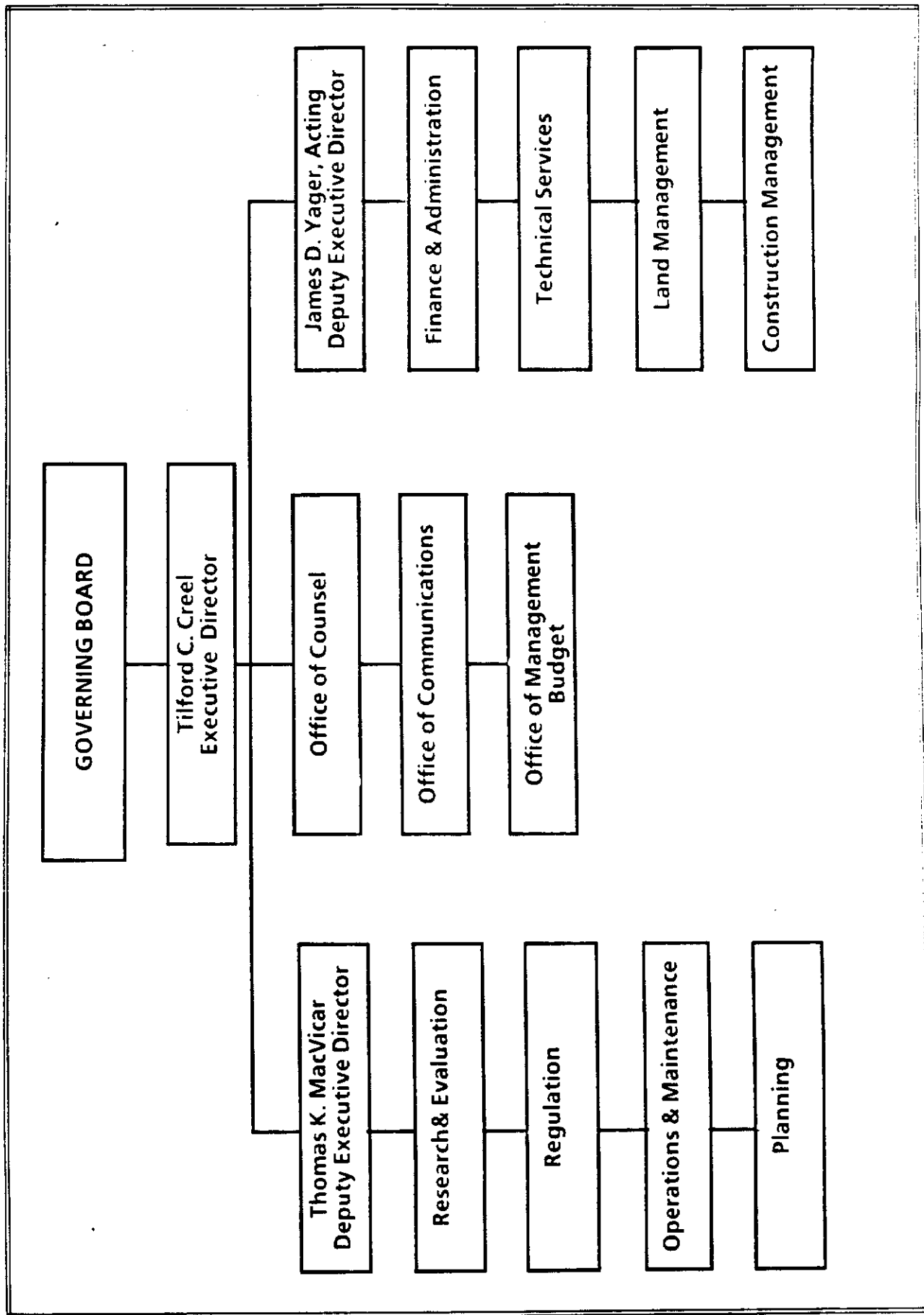


FIGURE 4.1 SFWMD ORGANIZATION CHART

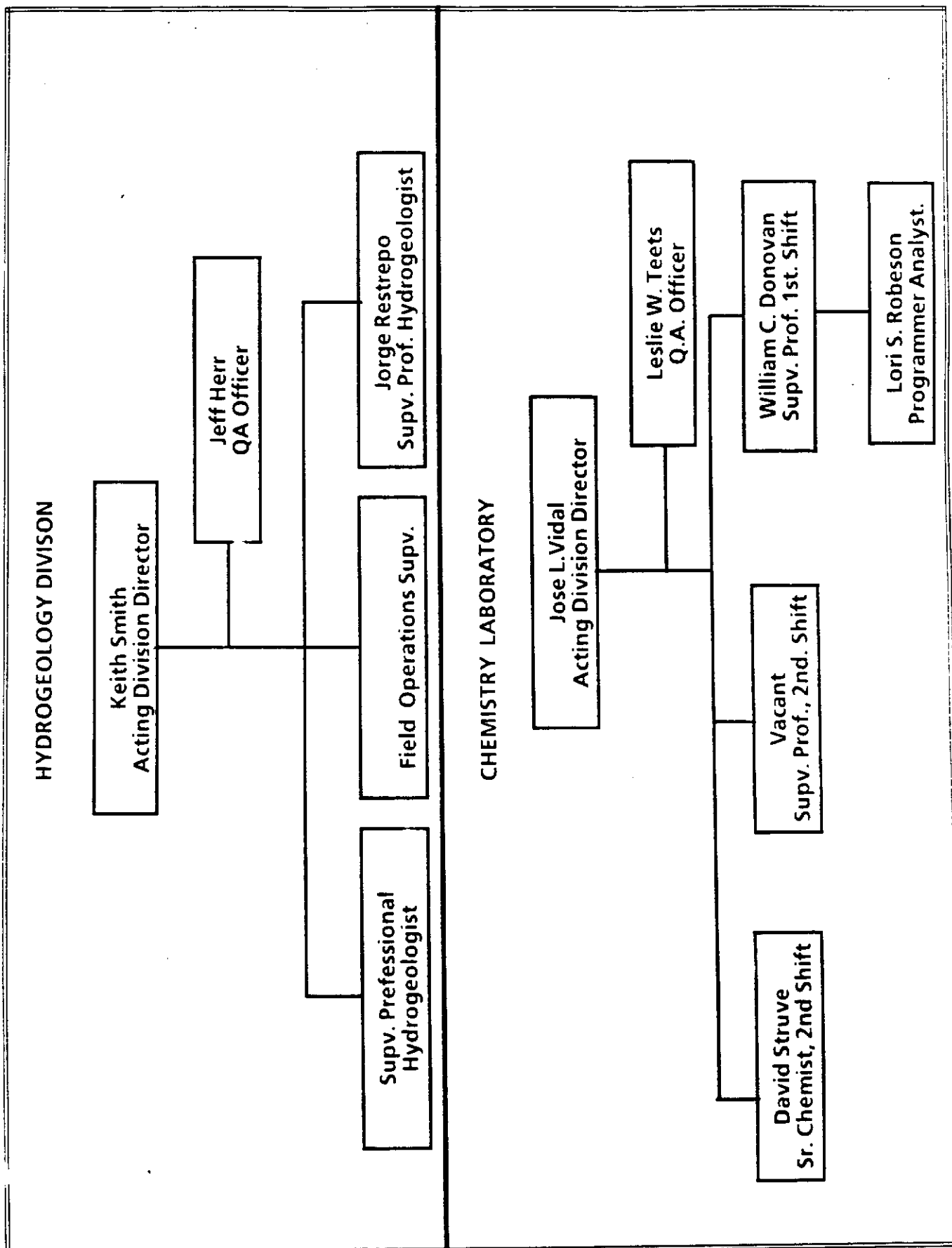


FIGURE 4.3 HYDROGEOLOGY AND CHEMISTRY LABORATORY DIVISION ORGANIZATION CHARTS

5.0 QA TARGETS FOR PRECISION, ACCURACY AND METHOD DETECTION LIMITS

Table 5.1 presents the laboratory quality assurance objectives and Table 5.2 presents the field quality assurance objectives used by SFWMD. The data is generated from historical data collected in the laboratory and field.

Table 5.1 (cont'd) - QUALITY ASSURANCE OBJECTIVES

Component	Matrix	Analytical Method #	Precision % RSD	Accuracy % Recv	MDL mg/L
Total phosphorus	Surface H ₂ O Ground H ₂ O	SM 424G	0 - 11.6	89.2 +/- 22.0	0.004
Orthophosphate	Surface H ₂ O Ground H ₂ O	SM 424G	0 - 10.6	98.7 +/- 18.2	0.004
Potassium, dissolved	Surface H ₂ O Ground H ₂ O	SM 303A	0 - 6.8	102.9 +/- 8.6	0.2
Residue, filterable	Surface H ₂ O Ground H ₂ O	SM 2098	0 - 83.4	NA	1
Residue, nonfilterable	Surface H ₂ O Ground H ₂ O	EPA 160.2	0 - 17.1	NA	1
Residue, volatile	Surface H ₂ O Ground H ₂ O	EPA 160.4	0 - 57.2	NA	1
Silica, dissolved	Surface H ₂ O Ground H ₂ O	SM 425C	0 - 10.9	102.0 +/- 10.8	1.0
Sodium, dissolved	Surface H ₂ O Ground H ₂ O	SM 303A	0 - 8.1	100.3 +/- 6.2	1.0
Strontium, dissolved	Surface H ₂ O Ground H ₂ O	SM 303A	0 - 2.6	97.0 +/- 14.4	0.2
Sulfate	Surface H ₂ O Ground H ₂ O	EPA 300.0	0 - 14.4	100.3 +/- 18.8	2.0

Table 5.1 (cont'd) - QUALITY ASSURANCE OBJECTIVES

Component	Matrix	Analytical Method #	Precision % RSD	Accuracy % Recv	MDL
Lead, total and dissolved	Surface H ₂ O Ground H ₂ O	EPA 239.2	0 - 12.6	92.1 +/- 32.0	0.5 ug/L
Barium, total and dissolved	Surface H ₂ O Ground H ₂ O	EPA 208.2	0 - 9.6	87.2 +/- 41.0	2.0 ug/L
Hardness	Surface H ₂ O Ground H ₂ O	SM 314B	0 - 12.6	92.1 +/- 32.0	5 mg eq CaCO ₃ /L
Color	Surface H ₂ O Ground H ₂ O	SM 204A modified	0 - 6.0	NA	1 Pt-Co unit
pH	Surface H ₂ O Ground H ₂ O	SM 423	0 - 6.5	NA	0.5 pH unit
Specific Conductance	Surface H ₂ O Ground H ₂ O	SM 205	0 - 5.6	NA	10 uS
Turbidity	Surface H ₂ O Ground H ₂ O	SM 214A	0 +/- 8.8	NA	0.1 NTU

6.0 SAMPLING PROCEDURES

6.1 Sampling Capabilities

The sampling capabilities of SFWMD are shown in Table 6.1. The reference used in developing sampling procedures is the EPA Region IV Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual (1986). This reference is available in the field and is referred to in this document as EPA SOP & QAM.

Table 6.1 Sampling Capabilities by Major Category

Matrix	Parameters
Surface Water	Nutrients Trace metals Major anions/cations Physical (classics) Pesticides/herbicides Semivolatile organics Volatile organics
Ground Water	Nutrients Trace metals Major anions/cations Physical (classics) Pesticides/herbicides Semivolatile organics Volatile organics Microbiological
Soil/sediments	Pesticides/herbicides Priority pollutants Trace metals

Samples are collected from the least to most contaminated areas whenever possible. Time limitations and distance between sites may make this impossible. However, the majority of the District sampling sites are ambient water sources with little variation in concentration levels within a sampling trip. For groundwater sampling, if a well is suspected to have free product, then it is not sampled.

The preferred order of sample collection is: 1) VOC, 2) POX, 3) TOX, 4) TOC, 5) extractable organics, 6) total metals, 7) dissolved metals, 8) microbiological, 9) inorganics,

and 10) turbidity.

6.2 Field Equipment

6.2.1 Surface Water Sampling Equipment

The following is a list of the equipment used for inorganic surface water quality sampling.

Sample collection devices

1. Wildco 2.2 liter acrylic vertical sampling bottle
2. Wildco 2.2 liter PVC horizontal sampling bottle
3. Wildco 3.2 liter PVC horizontal sampling bottle

The sampling bottles are all equipped with brass messengers and waterproof lines as supplied by Wildco (Wildlife Supply Co.).

Field instrumentation

1. Hydrolab Model 4031
2. Hydrolab Model 4041
3. Hydrolab Surveyor II
4. Hydrolab Surveyor III

Navigational aids

1. Apelco DXL 6000 Loran with antenna and battery
2. County road maps
3. Project location maps
4. WMD low band radio for communication

Boating supplies

1. Safety equipment: life vests, horn, flare kit, oars, fire extinguisher and throwable cushion
2. Spare tire for trailer
3. Engine oil

Notes:

1. This equipment does not contact the water within the well or sample water at any time. There is no possibility of water that has come in contact with this equipment coming in contact with water within the well or sample water.
2. This equipment does not routinely contact the water within the well and never contacts sample water at any time. The possibility of water that has come in contact with this equipment coming in contact with water within the well is minimized by the use of a drop pipe with a check valve. The purge pump is kept running while the drop pipe is withdrawn from the well to reduce the possibility of water draining back into the well from the inside of the suction hose.
3. This equipment contacts water within the well. It is cleaned in the laboratory and stored in aluminum foil until used. The cleaning procedures are dependent on the parameters being collected. The cleaning operations are recorded in the equipment logbook. Prior to the collection of the samples, the well is bailed with a Teflon bailer to remove the top 5 feet of water or approximately 2.5 gallons whichever is less.
4. This equipment contacts water within the well prior to the purging process. All water that contacts this equipment is removed during the purging process. This tape is cleaned with LiquinoxTM, rinsed with analyte free water, rinsed with isopropanol and rinsed again with analyte free water prior to use in the well. This operation is recorded and dated in the equipment logbook.
5. This device does not come in contact with the well or sample water at any time. It sends a sonic pulse down the well that is reflected off the surface of the water. The unit calculates the distance to the water surface by measuring the amount of time required for the sonic pulse to return to the sensor. It is temperature compensated so that changes in air temperature do not affect the accuracy.
6. This equipment is cleaned in the office and stored in aluminum foil until use. The cleaning procedures are dependent on the parameters that are being collected. This operation is recorded and dated in the equipment logbook.
7. Disposable, used once and discarded. Individually packed in plastic bags to prevent contamination prior to use.
8. Neither the peristaltic pump or TygonTM tubing contacts the well or sample water at any time. This pump is used to force air into the top of the Norwell bailer which turn forces the water through the QED FF 8200 filter. The top two inches of water in the bailer, approximately 100 milliliters, is discarded because it was in contact with the air in the bailer.

Coolers with wet ice

1. Igloo 48 quart
2. Gott 60 quart
3. Gott 80 quart
4. Igloo 84 quart
5. Igloo 196 quart

QA/QC supplies

1. Field spiking solutions in test tubes (prepared by lab)
2. Three (3) liters analyte free water

Miscellaneous supplies

1. Five (5) liter polyethylene bucket
2. Disposable gloves, PVC or latex, powder free
3. Polyethylene trays
4. Sample tags
5. #16 rubber bands
6. Waterproof pens (Sharpies)
7. Clipboard
8. Field notebook (bound, waterproof)
9. Chemistry field data log sheets
10. Secchi disc
11. First aid kit
12. Watch
13. Personal protective equipment

6.2.5 Autosampler Equipment

The following types of autosamplers are used.

1. American Sigma STREAMLINE Model 700
2. American Sigma Model 6201

6.3 Decontamination Procedures

All sampling equipment is transported to the field pre-cleaned and ready to use. Cleaning procedures are described in Section 6.3.1 and are as required by EPA SOP & QAM, Appendix B.

Analyte free water is obtained from the laboratory or field prep areas which have water purification systems. Analyte free water is generated to provide a source of water in which all interferences and analytes are below detection limits. Field personnel use analyte free water to prepare field blanks, equipment blanks, and for the final decontamination rinse of

rinse the bailer.

The suction hose and teflon coated stainless steel cable that are cleaned in the field are washed with Liquinox™ detergent, thoroughly rinsed with analyte free water, washed with isopropyl alcohol, and rinsed thoroughly again with analyte free water and stored in a clean container for transport to the next site. The isopropyl alcohol is allowed to evaporate on an impermeable surface.

6.3.5 Sediment Equipment

The field sampling equipment is cleaned prior to being taken to the field and in the field by the same procedure. The dredge, scoop, and bowl are washed with Liquinox™ detergent, rinsed three times with tap water, rinsed with analyte free water, rinsed twice with pesticide grade isopropyl alcohol, rinsed with analyte free water and allowed to air dry. The isopropyl alcohol is allowed to evaporate on an impermeable surface.

6.3.6 Bottles and Filter Holders

The reusable bottles and filter holders are detergent washed with Liquinox™, hot tap water rinsed, acid rinsed with 10% hydrochloric acid, alkali rinsed with pH > 12 sodium hydroxide solution (required due to galvanized drain line in wash area), tap water rinsed, analyte free water rinsed, and air dried. Dry bottles are stored with the caps on and filter holders are stored in a closed container.

Polyethylene trace metal bottles are detergent washed with Liquinox™, hot tap water rinsed, soaked in 20% nitric acid overnight, tap water rinsed, analyte free water rinsed, and stored with deionized water containing 1% nitric acid.

The filter holders are soaked in a weak sodium hypochlorite solution following their use in the field prior to laboratory washing. This is done to protect the laboratory from any bacteria which may be in the filter holders from the sampling process.

Bottles for the collection of samples sent to contract laboratories are provided by the laboratory which will be performing the analyses. They have been cleaned by the contract laboratory according to that laboratory's procedures prior to shipment to the District. The laboratory must have approved cleaning procedures in their Comprehensive Quality Assurance Plan.

6.3.7 Autosamplers

All autosampler bottles are cleaned in the laboratory using the standard bottle cleaning procedure described in Section 6.3.1 as per EPA SOP & QAM guidelines, Appendix B,

6.4.2 Surface Water - Organics

Surface water samples collected for organic analysis do not require any sampling equipment. Samples are collected mid-canal using a small boat and/or subsurface grab sampler. The sample containers are immersed inverted to 0.5 meter below the surface, turned upright pointed in the direction of flow, until full.

Volatile organic samples are collected in 40 mL Teflon-lined septum glass vials. The water sample is poured slowly down the edge of the sample vial to minimize aeration. The vial is filled to the point of creating a convex meniscus. The septum is placed, teflon side down, on the meniscus and sealed with the screw cap. The vial is inverted and lightly tapped on the lid to dislodge any entrapped air bubbles. The absence of air bubbles indicates a proper seal. If air bubbles are present, the bottle is opened, additional sample is added and the vial is resealed. Additional sample is added a maximum of three times, if a seal cannot be obtained, the vial, sample, and septum are discarded, a new vial is used and the sampling procedure is repeated.

Each sample is identified by the project code and sequential sample number. During sample collection, the date, time location, water movement, weather and site conditions are recorded. The preservation technique and holding times are shown in Table 6.3. Following collection of the sample, the bottles are sealed, tagged, and put in wet ice.

The samples are sent to the contract laboratory along with appropriate sample identification and chain of custody form provided by the contract laboratory. The samples are packed in coolers with bubble-wrap or other appropriate packing material to avoid breakage. Samples are kept at 4°C with wet ice. Sample for VOC analysis are placed into a separate bubble-pack bag for each station. Coolers are taped shut with shipping tape and shipped to the laboratory using common carrier overnight delivery.

6.4.3 Surface Water - Autosamplers

Water quality autosamplers are used for the collection of daily composite samples at selected sample sites. The sampling procedure is controlled by the automatic sampler programming. The automatic sampler, American Sigma Model Streamline 700, Program Version 3.1, is programmed to rinse the sample collection tubing twice prior to sample collection and to purge the tubing following collection. The samplers are programmed for daily composite to collect an 80 mL sample at 144 minute intervals and add it to the correct composite sample bottle for a total of 10 samples per bottle. Samples are analyzed for total Kjeldahl nitrogen and total phosphorus only.

The sampler intakes at tributary sites are positioned six to eight inches from the bottom to avoid contamination from bottom sediments and a minimum of eight to ten feet from the

homogeneous as possible. A precleaned stainless steel spoon or small scoop is used to take up the required amount of final homogenized material from near the center of the mass and it is promptly transferred, in order to prevent oxidation of metal ions or volatilization of organic compounds, into an amber, wide mouth, 8 oz. volume, glass jar with a Teflon-lined cap. The jar is filled to its rim. No additional aliquots are taken.

If analyses for pesticides, extractable organic compounds, or VOC are to be performed, the sample containers must be glass with teflon lined lids. For other classes of analytes, glass or plastic jars may be used as sample containers.

A special precaution that must be taken with sediment samples is to ensure that the containers are completely filled with sample and that air bubbles are not trapped in the container. This is necessary in order to minimize sample oxidation that could influence certain test results. The best way to minimize trapped air is to very gently pack the sample into the container with the spoon or scoop.

Field equipment is cleaned prior to the field trip and after each sample according to the procedures described in Sections 6.3.1 and 6.3.5.

6.4.5 Ground Water

6.4.5.1 Wells with In Place Plumbing

These wells are purged for a minimum of 15 minutes, until three bore volumes have been removed, or until the well has chemically stabilized, whichever is greater. The sample is taken from the faucet closest to source and before any screens, aerators, filters, etc. The flow rate is reduced to less than 500 mL/min when collecting samples to avoid any undue disturbance. Unfiltered and filtered samples are collected directly from the spigot.

6.4.5.2 Flowing Artesian Wells

These wells are purged until three bore volumes have been purged, or until the well has chemically stabilized, whichever is greater. The flow of water from the well is adjusted to minimize the aeration and disturbance of samples. Unfiltered and filtered samples are collected directly from the discharging water.

The samples are tagged and immediately placed on ice in a closed container. Exposure of the organic samples to sunlight is kept to a minimum. When organic samples other than TOC are collected, trip blanks are kept with the organic sample bottles to make certain that the samples have not become contaminated. These trip blanks accompany the samples from the time the empty sample bottles are shipped from the contract laboratory until the samples are analyzed. Trip blanks account for at least 5% of the samples that are analyzed.

The well is purged until a minimum of three standing water volumes are removed. The volume of water to be purged is calculated using the following terms: Depth of well (DW) in feet, depth to water (DTW) in feet, and casing diameter (D) in inches. The minimum purge volume (three water column volumes) in gallons, is given by:

$$\text{Minimum Purge Volume} = (D^2) * (DW - DTW) * 0.1224$$

The volume of water removed from the well must be calculated to avoid excess purging. The flow rate is estimated by measuring the amount of time required to fill a container of known volume. The required purge volume is then divided by the estimated flow rate to find the estimated time necessary to purge the well. Flow is measured several times during purging to be certain that it does not change.

Though a minimum of three water column volumes must be purged, the well is not considered to be purged until the well has chemically stabilized. Temperature, pH and conductivity are monitored and readings are recorded at time intervals equal to the amount of time necessary to purge one half of the bore volume (at least five minutes). These measurements are made in a flow through chamber to minimize atmospheric contact with the sample. The well is considered to have chemically stabilized when three consecutive sets or readings are within the following ranges: temperature $\pm 0.2^{\circ}\text{C}$, conductivity $\pm 5\%$, and pH ± 0.1 unit.

The purge volume is noted in the field log. All measurements that were recorded while waiting for the well to stabilize are recorded in the field log. Only the final readings taken after the well had stabilized are input into the sample results database. The drop pipe is slowly raised while the purge pump is on to make certain that all of the water above the drop pipe inlet is purged. This procedure also minimizes the possibility of the back flow of water that had entered the drop pipe or suction hose.

Wells with low hydraulic conductivity sediments that can be purged dry at one liter per minute are not sampled because the water quality is not deemed to be representative of the aquifer water quality. The SFWMD does not sample wells, dry purged or slow recovery, for which recovery cannot be accomplished in 4 hours or less.

Prior to sampling a protective covering of visqueen plastic is placed on the ground at all sampling sites to reduce the potential for contamination. All samples are collected using a Teflon bailer. When handling bailers or sample containers, disposable latex gloves are worn. Prior to the collection of the samples, the well is bailed with a Teflon bailer to remove the top 5 feet of water or approximately 2.5 gallons whichever is less. This procedure is done to ensure that any water that was in contact with the PVC drop pipe has been removed. The bailer is suspended by a Teflon coated stainless steel lanyard that is field cleaned and reused. The lanyard is not allowed to touch the ground during sampling.

6.5 Documentation

The following is a list of the field records that are maintained.

1. Field Trip Checklist (surface water)
2. Chemistry Field Data Log
3. Bound field notebook (project specific)

6.6 Preservation

Holding times and preservation techniques for each parameter are given in Tables 6-3, 6-4 and 6-5.

Samples are preserved in the field at the time of sample collection either by using preservatives provided by the SFWMD laboratory or the contract laboratory. If sample containers are received with preservative from the contract laboratory, additional preservative is requested so it is available if needed. ACS reagent grade preservatives are used.

For unfiltered samples, the appropriate preservative is added to the sample bottle after the sample has been added. The bottle is capped and shaken after which a small amount of the sample is poured onto the pH (0 - 3 pH units) test strip to ensure $\text{pH} < 2$. If pH is not < 2 , additional acid is added drop-wise, the bottle is capped and shaken, and the pH is tested again. This procedure is followed until $\text{pH} < 2$. The pH is checked on all samples requiring preservative and the same amount of acid is added to the equipment blank. The amount of acid added is recorded in the field notebook.

For filtered samples, the acid is added after filtration following the procedure outlined for unfiltered samples.

Fresh preservatives are obtained from stocks weekly for routine SFWMD sampling trips for samples submitted to the SFWMD laboratory.

6.7 Sample Dispatch

Samples to be analyzed by the SFWMD laboratory are submitted to the laboratory by the field personnel who collected the sample. The majority of samples are submitted the same day they are collected but all samples are submitted as soon as possible after collection in order to meet recommended holding times.

Samples to be analyzed by contract laboratories are shipped to the laboratory by common carrier overnight delivery the same day they are collected. All samples are carefully packed

Table 6.4. Holding Time and Preservation for Water Inorganics¹

Parameter	Holding Time	Preservative	Container & Size
Alkalinity	14 days	Cool, 4°C	Plastic, 60 mL
Ammonia	28 days	Cool, 4°C, pH<2(H ₂ SO ₄)	Plastic, 60 mL
Chloride	28 days	None required	Plastic, 60 mL
Color	48 hours	Cool, 4°C	Plastic, 60 mL
Fluoride	28 days	None required	Plastic, 250 mL
pH	Analyze immediately	None required	Plastic, 250 mL
Kjeldahl nitrogen	28 days	Cool, 4°C, pH<2(H ₂ SO ₄)	Plastic, 250 mL
Mercury	28 days	pH<2(HNO ₃)	Plastic, 250 mL
Metals	6 months	pH<2(HNO ₃)	Plastic, 250 mL
Nitrate + nitrite	28 days	Cool, 4°C, pH<2(H ₂ SO ₄)	Plastic, 60 mL
Nitrate	48 hours	Cool, 4°C	Plastic, 60 mL
Nitrite	48 hours	Cool, 4°C	Plastic, 60 mL
Orthophosphate	48 hours	Filter immediately, cool, 4°C	Plastic, 60 mL
Total phosphorus	28 days	Cool, 4°C, pH<2(H ₂ SO ₄)	Plastic 250 mL
Residue, filterable, nonfilterable, volatile	7 days	Cool, 4°C	Plastic 250 mL
Silica	28 days	Cool, 4°C	Plastic, 60 mL
Specific conductance	28 days	Cool, 4°C	Plastic, 60 mL
Sulfate	28 days	Cool, 4°C	Plastic, 60 mL
Turbidity	48 hours	Cool, 4°C	Plastic, 250 mL
Chlorophyll	(i) 24 hours to filter (ii) 21 days after filtration	(i) Cool, 4°C, dark, filter with MgCO ₃ , (ii) Filter frozen (until testing)	Plastic, 1 L

with appropriate material to prevent breakage. Insulated coolers are used for sample shipment and are sealed with shipping tape to avoid tampering. If samples must be kept at 4°C, wet ice is used.

6.8 Waste Disposal

All field generated wastes and contaminated purge waters are segregated and containerized for proper disposal including the use of the services of a commercial disposal company, if required. The SFWMD does not sample hazardous waste sites so the only field generated wastes are acids and isopropyl alcohol. The isopropyl alcohol is allowed to evaporate on an impermeable surface. Acids are diluted and/or neutralized and flushed down the sanitary sewer. The calibration standards for field parameters are flushed into the sanitary sewer.

6.9 Field Reagent and Standard Storage

Table 6-6 lists the storage procedures for reagents, standards and solvents.

Table 6-6. Reagent, Solvent and Standard Storage

<u>Chemical</u>	<u>Method of Storage</u>
Sulfuric Acid	Stored in original containers in vented acid storage cabinet. Note: Each acid is stored in a separate cabinet.
Nitric Acid	See above.
Hydrochloric Acid	See above.
Isopropyl Alcohol	Stored in original containers in vented solvent storage cabinet. No other solvents are stored in the same cabinet.
pH Standards	Stored in cabinet designated for standard and reagent storage. Cabinet is in air conditioned laboratory.
Conductivity Standards	Stored in cabinet designated for standard and reagent storage. Cabinet is in air conditioned laboratory.

FIGURE 7.1 - FIELD TRIP CHECK LIST

FIELD TRIP PREPARATION AND COMPLETION LIST

PROJECT NAME: _____ DATE: _____ PROGRAM CODE: _____
CHECK-OFF LIST:

- | | |
|--|----------------------------|
| _____ * Travel Request | _____ * Sign Out Vehicle |
| _____ * Sign Out Board | _____ * Gas Vehicle |
| _____ * Maps | _____ * Maintenance Check |
| _____ * Vehicle Packet/Credit Cards | _____ * Coolers/Ice |
| _____ * Field Notebook | _____ * QC Spikes |
| _____ * Gate Keys | _____ * DI Water for QA/QC |
| _____ * Header Sheets/Clipboard | _____ * Syringes |
| _____ * Pencils/Sharpies | _____ * Loaded Filters |
| _____ * Tags/Rubber Bands | _____ * Sampling Bottle |
| _____ * Calibrated Hydrolab/Battery | _____ * Clean Buckets |
| _____ * Secchi Disc | _____ * Preservatives |
| _____ * pH Test Strips | _____ * Goggles, Gloves |
| _____ * Bottles: 1L- _____ 250ml- _____ 60ml- _____ 175ml- _____ | |
| 250ml TM _____ | |

BOAT SUPPLIES

- _____ * Boat Box(Keys, Flares, Boat Registration)
- _____ * Life Vest for Every Passenger, Throwable Cushion
- _____ * Oars, Fire Extinguisher(left on board)
- _____ * Boat/Trailer: Fuel, Oil, Bearings, Tires, Hitch, Chain
- _____ * District Radio
- _____ * Loran/Antenna/Coordinates
- _____ * Spare Tire(fixed on trailer, check pressure)

PERSONAL ITEMS

- | | | |
|---------------|----------------------------|------------------------|
| _____ * Watch | _____ * Sunglasses | _____ * Drinking Water |
| _____ * Hat | _____ * Sunscreen | _____ * Rain gear |
| _____ * Food | _____ * Mosquito Repellent | |

POST TRIP PROCEDURES

- _____ * Sort Samples in Sequence and by Tag Color
- _____ * Place Samples in Refrigerator
- _____ * Sign Chain of Custody on Header Sheet
- _____ * Get Manager's Initials on Header Sheet & Turn In to Lab
- _____ * Place Sample #'s in Logbook
- _____ * Return Spike Tubes to Lab
- _____ * Return Clean Bottles to Bins in Trailer
- _____ * Separate Filter Holders and place in Soak Solution
- _____ * Return Dirty Bottles to Lab
- _____ * Rinse Sampling Bottle with D.I. Water and Store
- _____ * Replace Water in Hydrolab Stand(Tap Water Only!)
- _____ * Clean Out Vehicle
- _____ * Store All Boat Supplies/Loran
- _____ * Park Boat/Drain Plug Out
- _____ * Park Vehicle/Fill Out Trip Ticket/Return Keys
- _____ * Return Field Notebook to Supervisor's Office
- _____ * Report any Equipment Problems to Supervisor
- _____ * Give copy of Header to Supervisor
- _____ * Turn in Prep List to Supervisor

INITIALS: _____

**FIGURE 7.3 -
SAMPLE SUBMISSION DIAGRAM FOR FILTERED WATER**

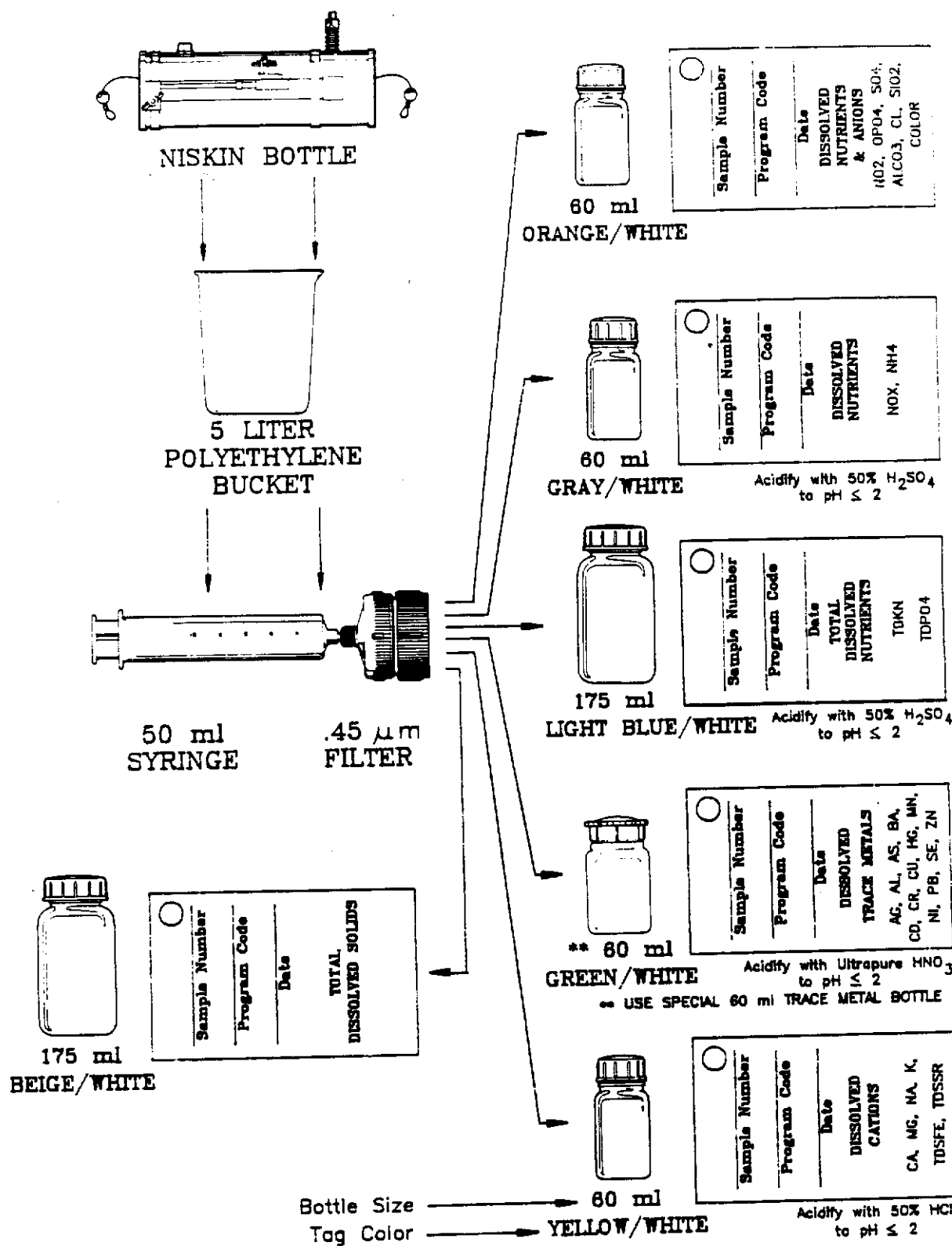


FIGURE 7.5 - SAMPLE LOG-IN TO LIMS

SFWMD LABORATORY DHRS CERTIFICATION # E46077

DISPLAY

PAGE 01

01 - SAMPLE NUMBER : 91011431

03 - PROJECT CODE : CAMB4

04 - C/LAS TYPE : 1

05 - PROJECT CODE : CAMB

06 - SUBMITTER : JJ

07 - CHARGE NUMBER : SL25

08 - FIELD SAMPLE NUMBER : E245

09 - DATE COLLECTED : 072391

02 - PRIORITY : 0

10 - TIME COLLECTED : 1008

11 - STATION CODE : S333

12 - UP/DOWN STREAM : 1

13 - DISCHARGE : 1

14 - WEATHER : 1

18 - DISSOLVED OXYGEN : 1.3

15 - SAMPLE TYPE :

19 - SPEC. CONDUCTIVITY : 663

16 - DEPTH : 0.5

20 - PH : 6.50

17 - TEMPERATURE : 29.2

21 - SECCHI DISC :

22 - SAMPLE DESCRIPTION :

23 - OX/RE POT. :

SFWMD LABORATORY DHRS CERTIFICATION # E46077

DISPLAY

REQUIRED ANALYSIS

ITEM	TEST #	SVC GRP	# REPS	TEST DESCRIPTION
01	TURB	PP	01	TURBIDITY IN NTU'S (00076)
02	TKN	CF	01	TOTAL KJELDAHL NITROGEN MG N/L (00625)
03	TP04	CF	01	TOTAL PHOSPHORUS MG P/L (00665)
04	COLOR	PP	01	COLOR (00080)
05	OP04	CF	01	ORTHOPHOSPHATE MG P/L (00671)
06	N02	FI	01	NITRITE MG N/L (00615)
07	ALCO3	FI	01	ALKALINITY MG/L AS CaCO3 (00410)
08	CL	FI	01	TOTAL CHLORIDE MG/L (00940)
09	NOX	FI	01	NITRITE PLUS NITRATE MG N/L (00630)
10	NH4	FI	01	AMMONIA DISSOLVED MG N/L (00608)
11	CA	AA	01	DISSOLVED CALCIUM MG/L (00915)
12	MG	AA	01	DISSOLVED MAGNESIUM MG/L (00925)
13	NA	AA	01	DISSOLVED SODIUM MG/L (00930)
14	K	AA	01	DISSOLVED POTASSIUM MG/L (00935)

FIGURE 7.8 - FIA LOG



FIA Sample Log Form

Technician: _____ Date: _____

Output File Name: _____ Disk Number: _____

Parameter: _____ Gain: _____

Parameter: _____ Gain: _____

Parameter: _____ Gain: _____

Parameter: _____ Gain: _____

Sample Numbers (including REWORKS):

Comments: _____

CALIBRATION:

CHANNEL 1: _____		CHANNEL 2: _____		CHANNEL 3: _____	
STANDARD CONCENTRATION	INSTRUMENT READING	STANDARD CONCENTRATION	INSTRUMENT READING	STANDARD CONCENTRATION	INSTRUMENT READING
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

QUALITY CONTROL

QC1: _____
QC2: _____
C.V.: _____
STAD: _____

GAIN: _____

FIGURE 7.10 - PHYSICAL PARAMETERS LOG



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Calibration Log for Physical Parameters

ANALYST: _____ DATE: _____
PARAMETER: _____

STANDARDS:

Known Value	Instrument Reading
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

REP NO. QUALITY CONTROL SAMPLES:

() QC1 True Value	QC2 True Value
() _____	() _____
() _____	() _____
() _____	() _____
() _____	() _____
() _____	() _____
() _____	() _____

REPEAT SAMPLE READINGS:

() _____	() _____	() _____	() _____
() _____	() _____	() _____	() _____
() _____	() _____	() _____	() _____

SAMPLES ANALYZED: _____

7.2.2 Sample Transmittal

The Chemistry Field Data Log and examples of the sample tags are shown in Figures 7.2 through 7.4. The Chemistry Field Data Log includes the field ID number, date and time of sample collection, station (site) code, intended analyses, method of preservation, and limited comments about the sample or sample container. Sample seals are not used.

7.3 Laboratory Operations

The samples are brought to the laboratory by the field sampling personnel and put into the designated refrigerator. The person bringing them to the laboratory signs and dates the Chemistry Field Data Log. The Chemistry Field Data Logs are given to the person responsible for logging-in the sample. The information from the Chemistry Field Data Log is entered into the LIMS and a laboratory sample number is generated by LIMS consisting of eight (8) digits, 2 for the year and 6 for the sequential log-in number, ex: 91010975 is sample 10,975 logged-in in 1991. The person logging-in the samples records the LIMS numbers on the Chemistry Field Data Log, initials and dates the form at the time the samples are logged. The LIMS numbers, date logged, and initials of the logger are also maintained in a bound laboratory notebook. A computer-generated list is obtained with the respective field and LIMS numbers for each sample.

Labels for each aliquot are generated by LIMS and are manually attached to the sample field tag. As each sample is labeled, the technician checks the proper match of field and LIMS numbers, and the sample bottle for leakage, cracks, and any other obvious faults. Five percent of the samples (at least one from each batch) are checked for proper preservation. The results of this check are documented in a bound notebook.

7.3.1 Sample Rejection

Samples are rejected if the bottle is leaking or cracked, if there is no Chemistry Field Data Log submitted with the samples, or if the Chemistry Field Data Log is incomplete.

7.3.2 Sample Security, Accessibility, and Storage

The samples are accessible to the laboratory staff during working hours. The door to the exterior of the building and the door to the main hallway are locked when the last member of the staff leaves for the day. The door to the sample receiving area is opened at 7:00 A.M. The only persons authorized to be in the laboratory are the laboratory staff and the sampling personnel delivering samples. All visitors must be escorted by a member of the laboratory staff.

Samples are stored in refrigerators designated for sample storage only. No VOC's are stored in the laboratory refrigerators and standards are stored in refrigerators designated

Back up of the system is performed weekly with one complete set of tapes stored off-site so that in the event of catastrophe, only one week of data would be lost.

7.4.2 Forms

The only forms printed by the computer which required verification and signature are the weekly data results sent to project managers. They review the data, identify tests for rework or field sample data for modification, sign the printout and return it to the laboratory. These copies are stored by date produced and are kept according to the record management standards.

7.4.3 Electronic Data Transfer

All requests for copies of the data, electronic or hard copy, are made through the appropriate project manager. All data at SFWMD is public information. The project manager is responsible for requesting the data and submitting it to the requestor. For all data transmitted electronically, (e.g. by modem, or diskettes), hard copies are sent via mail following data transmittal.

7.4.4 Documentation and Verification

All LIMS documentation is maintained by the Programmer Analyst who is responsible for maintaining the documentation records and the maintenance logs. The documentation for all instrument software is located in the laboratory at the instrument. Software problems are included in the maintenance log for the instrument. Software revisions are installed and the records maintained by the Programmer Analyst.

Software is verified by comparing the results generated by the new software to the results from the old software for at least six analytical runs. The evaluation of the results must yield no significant statistical difference. The QC results are also used to show that the software is performing correctly.

Data entry is verified by comparing the results obtained by the instrument software to the results entered into the database. Manual data entry is verified by comparing the results in the database to the results on the data entry forms.

results regardless of which technician performs the analysis. The procedure used is given in Appendix A.

8.4 Laboratory Reagent Storage

The storage of the laboratory reagents and chemicals is given in Table 8-1.

Table 8-1. Reagent and Chemical Storage

<u>Chemical</u>	<u>Method of Storage</u>
Mineral acids	Stored in original containers in vented cabinet designed for acid storage. Note: each acid is stored in a separate cabinet.
Liquid bases	Stored in original containers in a vented cabinet designed for corrosive storage.
Organic solvents	Stored in original containers in a vented cabinet designed for flammable storage in the outside storage area.
Compressed gases	Stored in original containers in the compressed gas storage area in the outside storage area.
Dry chemicals	Stored in original containers segregated by reactivity in the dry chemical storage area.

As each chemical is received, it is dated and initialed by the person unpacking it. When a new container is opened for use, it is dated and initialed by the person who opened it.

8.5 Waste Disposal

The laboratory has a designated hazardous waste storage area outside the laboratory. The process wastes containing mercury and phenol are collected for disposal by a hazardous waste company. As each waste is generated, the volume is entered on the monthly hazardous waste report required by the SFWMD Risk Management Division. When the volume collected reaches the level set by Risk Management, it is moved to the SFWMD hazardous waste storage area. The Risk Management Division is responsible for securing the services of the waste disposal company.

Any small amounts of reagents are transferred to the hazardous waste storage area as they expire or are no longer needed. The waste disposal company then picks them up for proper

9.0 Calibration Procedures and Frequency

9.1 Instrumentation Lists

The following is a list of the laboratory instrumentation.

<u>Manufacturer</u>	<u>Model and Description</u>
Hach	Model 18900 Ratio Turbidimeter
Fisher	Model 805MP pH Meter
Radiometer	CDM83 Conductivity Meter
Mettler	P160 Top Load Balance H43 Analytical Balance AE163 Analytical Balance
Bausch & Lomb	Spectronic 501 Visible Spectrophotometer
Dionex	4000i Ion Chromatograph
Alpkem	(3) RFA300 Rapid Flow Analyzers with PC Workstation
Lachat	Flow Injection Analyzer with PC Workstation
Perkin Elmer	1100B Flame Atomic Absorption Spectrophotometer with PC Workstation Z5100 Furnace Atomic Absorption Spectrophotometer with PC Workstation

The following is a list of the field instrumentation.

<u>Manufacturer</u>	<u>Model and Description</u>
Hydrolab	Model 4031 pH, Conductivity, ORP, and Temperature Meter Model 4041 pH, Conductivity, DO, and Temperature Meter Model Surveyor II pH, Conductivity, DO, Temperature, Salinity, ORP and Depth Meter Model Surveyor III pH, conductivity, DO, Temperature, Salinity, ORP and Depth Meter

Table 9-1 Standard Sources and Preparation

Instrument Group	Standard Sources	How Received	Source Storage	Preparation from Source	Lab Stock Storage	Preparation Frequency
Atomic Absorption	Spex	Solutions of 1000 mg/L	Room temperature	Primary stocks (>1 mg/L) prepared from source Working stocks	0.15% HNO ₃ at room temp. NA	Monthly or as needed Daily
Continuous Flow & Ion Chromatograph	Commercial lab supplier	Dry, ACS reagent grade	Room temperature	Primary stocks, 1000 mg/L prepared from source Working stocks	Refrigerator NA	Monthly Daily
pH Standards	Commercial lab supplier	pH 4,7,10 solutions	Room temperature	NA	NA	Replace on expiration
Conductivity Standards	Commercial lab supplier	200, 720, 1413, 2000 uS	Room temperature	NA	NA	Replace on expiration
Turbidity	Hach	Sealed Gel Standards	Room temperature	NA	NA	Annual replacement
Color	Commercial lab supplier	500 Pt-Co units	Room temperature	Working stocks	NA	Daily
Analytical balances	Commercial lab supplier	Class S weights	Dessicator, room temperature	NA	NA	NA

Table 9-3. Field Instrument Calibration (Hydrolabs¹)

Instrument Probe	# Standards Initial Calib.	Accept/Reject Criteria-Initial Calibration	Frequency	# Standards Continuing Calib.	Accept/Reject Criteria- Continuing Calib.	Frequency
pH	2 (1 pH 7 & 1 pH 4 or 10) ²	Reading within 0.1 pH unit	Daily prior to use or failure of cont. calibration	1	Concentration within 5% of known value	Initial and every 10 samples
Conductivity	1	Concentration within 5% of known value	Daily prior to use or failure of cont. calibration	1	Concentration within 5% of known value	Initial and every 10 samples
Dissolved Oxygen	Winkler titration	Concentration within 5% of known value	Annually	Saturated air	Concentration within 5% of known value	Daily prior to use and every 10 samples
Temperature	1	Concentration within 2% of known value (NIST thermometer)	Annually	1	Concentration within 5% of known value - lab calibrated thermometer	Quarterly

- (1) The Hydrolabs all have automatic temperature compensation for pH, conductivity and DO measurements.
(2) Buffer pH 4 or pH 10 solution used, respectively, with acidic or basic samples.

Table 10-1. Field Equipment Maintenance Schedule

Instrument	Specific Activity	Frequency
Hydrolabs (all models)	DO probe membrane and electrolyte changed	Quarterly
	Conductivity sensors are sanded with emery cloth	Quarterly
	pH and reference electrodes cleaned with methanol	Quarterly
	pH reference electrode refilled with 3M KCl	Monthly
	All outside surfaces cleaned and rinsed with analyte free water	Daily

Instrument	Specific Activity	Frequency
Visible Spectrophotometer	Clean flowcell	Daily
	Change pump tubes	Semiannual
Analytical Balances	Clean weighing compartment	After each use
	Calibration service & inspection	Semiannual
Ovens	Check temperature	Daily
	Calibrate thermometer to NIST thermometer	Annually
Refrigerators	Check temperature	Daily
	Calibrate thermometer to NIST thermometer	Annually
Digestion blocks	Check temperature	Weekly
	Calibrate thermometer to NIST thermometer	Annually

FIGURE 11.1 - FIELD QA/QC SAMPLE REQUEST FORM

This form is to be completed by project manager and returned to L. Teets A MINIMUM OF ONE WEEK PRIOR TO THE TRIP DATE.

PROJECT CODE :
SAMPLING TRIP DATE :

PROJECT MANAGER :
DEPARTURE TIME :

ANALYSES REQUESTED: check only those parameters that apply; spike solutions are not prepared for physical parameters.

250 ml BOTTLE/WHITE TAG:	LAB USE ONLY	LOT# OR STOCK PREP:
_____ F = 0.67	(2.0ml)(100mg/L HACH)/299mls	_____
250 ml bottle/MAGENTA TAG:		
_____ TKN = 3.34	(1.0ml)(1000mg/L STOCK)/299mls	_____
_____ TPO4 = 0.163	(3.0ml)(50mg/L HACH)/299mls	_____
_____ TOTFE = 0.42	(2.5ml)(50mg/L HACH)/299mls	_____
175 ml bottle/LT.BLUE TAG:		
_____ TDKN = 2.38	(3.0ml)(150mg/L HACH)/189mls	_____
_____ TDPO4 = 0.129	(1.5ml)(50mg/L HACH)/189mls	_____
60 ml bottle/GRAY TAG:		
_____ NOX = 0.169	(1.0ml)(12mg/L HACH)/71mls	_____
_____ NH4 = 0.35	(0.5ml)(50mg/L HACH)/71mls	_____
60 ml bottle/ORANGE TAG:		
_____ OPO4 = 0.115	(0.5ml)(50mg/L HACH)/71mls	_____
_____ ALCO3 = 112.7	[10,000mg/L]	_____
_____ CL = 112.7	(0.8ml) [10,000mg/L] COMPOSITE STOCK/71mls	_____
_____ SO4 = 56.3	[5,000 mg/L]	_____
_____ SI02 = 7.04	(2.0ml)(250mg/L HACH)/71mls *** SEE REVERSE	_____
60 ml bottle/YELLOW TAG:		
_____ CA = 28.2	[500 mg/L]	_____
_____ MG = 5.63	[100 mg/L]	_____
_____ NA = 28.2	(4.0ml) [500 mg/L] SPEX MN-4 Composite/71mls	_____
_____ K = 5.63	[100 mg/L]	_____
_____ TDSFE = 0.232	(2.0ml)(10mg/L HACH)/71mls	_____
_____ TDSSR = 1.41	(0.1ml)(1000mg/L SPEX)	_____

SOLUTIONS PREPARED BY:

DATE:

are prepared in the field and submitted to the laboratory with the routine samples for that project. Equipment blanks (F) are submitted and analyzed when sampling equipment is cleaned in the field and represent approximately 5% of the samples collected on those trips.

The spiking solutions for use in preparing field quality control check samples are prepared by the laboratory QA officer. Solutions are prepared as requested by the project managers. The left-hand margin of the Field QA/QC Sample Request form, shown in Fig. 11-1, is a check list of analytes for which spiking solutions have been requested. The spiking solutions are prepared using the stock solutions (purchased or prepared in-house) used to make daily calibration standards and quality control samples for laboratory QA activities.

Separate spiking solutions are prepared for each aliquot of the sample; the sample aliquots and their respective bottle size, preservation technique and tagging scheme is shown in Figs. 7-2 and 7.3. Portions of stock solutions for each analyte within a given aliquot are pipetted and combined in a 20ml Kimax test tube with Teflon lined screw-cap. The volumes of stock solutions used in preparing the spiking solutions are calculated so the amount of added analyte in the resultant spiked aliquot falls between the detection limit and the highest calibration standard of the respective analytical methods. The combined volume of stock solutions for each sample aliquot is designed to represent less than 5% of the sample bottle volume. Two sets of spiking solutions are prepared identically for each aliquot, one for the spiked sample and one for the spiked blank. A crucial aspect of this program is the use of the correct size bottle for sample collection. The bottle must be filled completely so the final dilution of the spiking solution is consistent. To establish the full-bottle volume of each size and type of bottle prescribed for sample collection, 10 randomly chosen bottles of each size and type were filled to full-volume. The volume of deionized water was measured using suitable sized graduate cylinders. The ten values obtained for each bottle within its group were used to calculate a mean bottle volume for each size and type bottle. Shown below are the mean bottle volumes of sample bottles used for collection:

Bottle Size	Mean Bottle Volume, n = 10
60ml	71ml
175ml	189ml
250ml	299ml
60ml(Trace Metals)	66ml
250ml(Trace Metals)	266ml

Once all solutions representing the requested analytes have been combined in test tubes, the tubes are capped and parafilm is wrapped around the seal to prevent the lids from coming lose during transport to the field. Spiking solutions are prepared the day before the trip date and refrigerated until departure time. During the sampling trip, the spiking solution test tubes are kept secure in a beaker in an ice chest.

Percent Recovery of QC Check Standards

$$\% \text{Recovery} = \frac{[\text{Experimental}]}{[\text{Known}]} * 100$$

The quality control data is kept in table format with new limits calculated quarterly. The field staff is given the control limits for each quarter for ready reference as samples are collected. The formulas for calculating control limits are based on the standard deviation of the last 30 measurements for each type of sample. The standard deviation is calculated according to the following formula.

$$s = \frac{\sum (X_i - \bar{X})^2}{\sqrt{n-1}}$$

where \bar{X} is the mean, X_i is an individual value, and n is the number of values.

$$\text{Mean} = \bar{X} = \frac{\sum X_i}{n}$$

The limits for field parameters are 2s for warning limits and 3s for control limits.

11.4.2 Lab Reportable Data

The precision and accuracy of each parameter are measured on a daily basis. The field spikes, blanks, and replicates are analyzed as routine samples and are not identified to the analyst prior to testing.

Accuracy can be defined as the agreement between the actual obtained result and the expected result. Two QC check samples, QC1 and QC2, having a known or "true" value and standard additions also with an expected result, are used to test for the accuracy of a measurement system. Accuracy may be quantified by comparing results obtained for QC1 and QC2 to their true values and calculating a percent recovery using the following equation:

$$\text{Percent Recovery} = \%R = \frac{\text{experimental result}}{\text{"true" value}} * 100$$

The values obtained for the matrix spike are used to calculate percent recovery using the following equation:

$$\text{Percent Recovery} = \%R = \frac{[\text{matrix spike}] - [\text{sample}]}{[\text{spike}]} * 100$$

Table 11.1 Field Quality Control Checks

Type	# Samples /Event	Frequency (All Parameter Groups)
Equipment Blank, Precleaned Eqpt.	> 10	1 prior to sampling, on-site 5% if >20 samples
	1-10	1 prior to sampling, on-site
Equipment Blank, Field Cleaned Eqpt.	> 10	1 blank or 5% of equipment cleaned, whichever is greater
	5-10	1 blank on equipment cleaned
	<5	1 on either precleaned or field cleaned eqpt.
Trip Blank (VOC only)	1 or more	1 for each volatile organic method
Field Duplicate	1 or more	1 or 10% of the samples, whichever is greater
Field Matrix Spike	1 or more	1 or 5% of the samples, whichever is greater
Field Blank Spike	1 or more	1 or 5% of the samples, whichever is greater
Field Blank	1 or more	1 or 5% of the samples, whichever is greater
Field Measurements (1) Duplicate	1 or more	(1)1 or 10% of the samples, whichever is greater
(2) QC Check Stds.		(2)1 or 5% of the samples, whichever is greater

Table 11.3. Procedures Used to Determine Precision and Accuracy

Method	Purpose	Concentration Level	Method References
Matrix Spike	Accuracy	Mid Level	Nutrients, Trace Metals, Anions, Cations
Duplicates	Precision	Low Level Mid Level High Level	All parameters
Replicate for analytical run	Precision	Mid Level High Level	All parameters
QC Check Samples	Accuracy	Mid Level High Level	All parameters
QC Check Standards	Accuracy	Low Level Mid Level High Level	All parameters for which a sample is available
Method Reagent Blank	Accuracy	Low Level	Total Nutrients and Total Metals
Mid-Range Check Standard	Precision and Accuracy	Mid Level	Nutrients, Trace Metals, Anions and Cations

sample identification, and the instrument/analytical logs for adherence to QC protocols and correct sample identification. The Laboratory Quality Assurance Officer is responsible for checking the calibration integrity by comparing the present instrument responses to the historical values and the internal chain of custody for the samples to identify that only authorized persons have analyzed or handled a sample.

12.2.2 Field Data Integrity

The Quality Assurance Officers for the Water Quality, Hydrogeology, and Environmental Sciences Divisions are responsible for checking calibration integrity by checking the calibration logs and comparing present values to historical values and the sample custody integrity by checking the paperwork to ascertain that only trained personnel took samples and that they were preserved and transported correctly. The Project Manager is responsible for checking raw data entries and calculations by reviewing the records for accuracy and use of proper formulas.

12.3 Specific Data Validation Procedures

12.3.1 Laboratory Data Validation

The analyst (Asst. Lab Technician, Lab Technician, Senior Lab Technician, or Chemist) is responsible for the first step in the validation process. It is his/her responsibility to follow the procedures correctly, perform the quality control checks, and report any discrepancies to his/her supervisor and/or the Laboratory Quality Assurance Officer. The Supervising Professionals are responsible for investigating the discrepancy and determining the cause. The Supervising Professionals are also responsible for the review of all data to identify obvious anomalies. The Laboratory Quality Assurance Officer is responsible for reviewing the quality control results and updating the acceptable limits tables for all parameters.

The laboratory quality control checks are used to validate the laboratory results. Each of the QC check samples will be discussed.

Method Reagent Blank - if the result is greater than the detection limit, the run is stopped and the blank is prepared again. All samples since the last acceptable blank are reanalyzed.

Matrix Spike Sample - if the result is outside the current acceptable limits, the sample will be prepared again. If the value is outside the range again, it is noted that the sample exhibits matrix interference.

Quality Control Check Standards - if the result is outside the current acceptable limits, the run is stopped and the instrument recalibrated. If necessary new calibration standards are prepared and the instrument is checked for leaks, cracks in tubing, correct reaction

12.3.3 Project Data Validation

The Project Manager is responsible for the final review of data and its release to the database and to requestors. The Laboratory Quality Assurance Officer is responsible for review of the laboratory QC data and the divisional Quality Assurance Officer is responsible for reviewing the field quality control data for projects in her/his division. The Project Manager is responsible for review of all supporting documentation and the review of the data for anomalous results.

12.4 Data Reporting

Following the data validation, the results are entered in the SFWMD water quality data base by the Analysts (Asst. Lab Technician, Technician, Senior Lab Technician or Chemist). The Supervising Professional Chemists check entered data, by means of automated computer programs, to ensure detection of aberrant data, e.g., $\text{NO}_2^- > \text{NO}_3^-$, to avoid its inclusion into final reports. All reports are generated electronically from this data base by the Water Quality Division Programmer Analysts or Project Managers. Printouts are routinely generated for all electronically transmitted data.

All requests for data reports must be made through the Project Manager. He/she is responsible for reviewing the data before it is released to the requestor.

A sample copy of a final report is shown in Figure 12-1.

12.5 Data Storage

The records that will be retained are the strip charts, chromatograms, data files, Chemistry Field Data Logs, manual data entry records, daily QC reports, instrumentation logs and LIMS back up tapes.

The hard copy information is retained in the laboratory for no more than one year. After that it is sent to warehouse records storage and will be microfilmed if storage for longer than three years is needed.

The magnetic tapes used for weekly back-up of the laboratory information management system are maintained in two sets. One set is kept in an in-house vault for immediate access and one set is sent to secure storage outside the SFWMD for recovery in the event of a catastrophic event.

Archived records are indexed based on date for hard copy laboratory records, and by project for field notebooks and results in the water quality database. The Project Manager is responsible for the storage of all project for at least three years.

13.0 Corrective Action

Corrective action is required in those cases when the criteria levels for the quality control measures are not met. The specific corrective action for each type of quality control measure is given in Tables 13.1 and 13.2.

The analyst (Asst. Lab Technician, Lab Technician, Senior Lab Technician or Chemist) or field sample collection technician (Asst. Scientific Technician, Scientific Technician, Senior Scientific Technician) is responsible for assessing each QC measure and initiating corrective action according to Tables 13.1 and 13.2, respectively. The Supervising Professional-Chemists, the Field Operations Supervisor, and the divisional Quality Assurance Officers are responsible for approving the corrective action taken or for initiating further steps to solve the problem.

External sources which may initiate corrective action are performance evaluation results, performance audits, system audits, split sample results, and laboratory/field comparison studies.

The problem and corrective action are documented in detail in one of the following: analysis logbooks, digestion logbooks, or instrument maintenance logs depending on the nature of the problem and how it was solved. The supervisor will report the problem to the appropriate Quality Assurance Officer who has the responsibility for determining if the solution is acceptable and if not, what further steps should be taken.

DER recommended corrective action will be initiated as a result of systems or performance audits, split samples or data validation review.

Table 13.2 Corrective Actions for the Field

QC Activity	Acceptance Criteria	Recommended Corrective Action
Initial Calibration Standards	Value within +/- 5% of expected value	Reanalyze standards, if same response, prepare new standards
QC Check Standards	Value within +/- 2 standard deviations of the historical value	Reanalyze QC check standard, if same response, prepare new QC check standard, if same response, recalibrate
Equipment/Trip Blanks	Value < MDL	Reanalyze blanks: If same response, check recorded cleaning procedures and mark sample trip results for affected and related parameters questionable or invalidate data, as required.
Field Spike Samples	Value within +/- 2 standard deviations of the historical value	Reanalyze field spikes: If same response check procedures, bottle size, concentration and spiking solution used; mark sample trip results for affected and related parameters questionable or invalidate data, as required.
Duplicate Samples	Second value is +/- 5% of first value	Reanalyze duplicates: If same response, mark sample trip results for affected and related parameters questionable or invalidate data, as required.

The audit may be conducted at any time on a suspect parameter in addition to the semiannual audits for the entire laboratory.

The results of the performance audits are included in the quarterly quality assurance reports issued by the Laboratory Quality Assurance Officer.

14.2.2 External Performance Audits

The laboratory laboratory participates in three external performance audit programs. They are:

1. Florida Environmental Laboratory Certification Program administered by the Department of Health and Rehabilitative Services, semiannual
2. United States Geological Survey, Denver, semiannual
3. United States Geological Survey, Ocala, quarterly or as received (frequency has varied in the past)

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General Sampling Procedures:

- | | <u>Yes</u> | <u>No</u> |
|---|------------|-----------|
| 1. Were sampling locations properly selected? | ___ | ___ |
| 2. Was sampling equipment protected from possible contamination prior to sample collection? | ___ | ___ |
| 3. If equipment was cleaned in the field, were proper procedures used? | ___ | ___ |
| 4. What field instruments were used? _____

_____ | | |
| 5. Were calibration procedures documented in the field notes? | ___ | ___ |
| 6. Were samples chemically preserved at time of collection? | ___ | ___ |
| 7. Were samples iced at time of collection? | ___ | ___ |

Comments: _____

Surface Water Sampling:

- | | <u>Yes</u> | <u>No</u> |
|--|------------|-----------|
| 1. What procedures were used to collect the surface water samples? _____

_____ | | |
| 2. Was a Niskin bottle used for sample collection? | ___ | ___ |
| 3. Was sample collected in polyethylene bucket? | ___ | ___ |
| 4. Did samplers wade in stream during sample collection? | ___ | ___ |

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- | | <u>Yes</u> | <u>No</u> |
|--|------------|-----------|
| 12. How were the samples collected? | | |
| Bailer? | ___ | ___ |
| Pump? | ___ | ___ |
| Other? Describe: _____ | | |
| _____ | | |
| _____ | | |
| 13. Construction material of bailer? _____ | | |
| 14. If a pump was used, describe how it was cleaned
before and/or between wells. _____ | | |
| _____ | | |
| _____ | | |
| 15. Were the samples properly transferred from bailer
to sample bottles (i.e., was the purgeable
sample agitated, etc.)? | ___ | ___ |
| 16. Was the rope or line allowed to touch the ground? | ___ | ___ |
| 17. Was a teflon rope used? | ___ | ___ |
| If no, what kind was used? _____ | | |
| Was it discarded after use at each well? | ___ | ___ |

Comments: _____

Sediment Sampling:

- | | <u>Yes</u> | <u>No</u> |
|--|------------|-----------|
| 1. What procedures were used to collect the samples? | | |
| _____ | | |
| _____ | | |
| _____ | | |
| _____ | | |
| 2. Were the samples well mixed prior to placing the
sample in the sample container? | ___ | ___ |
| 3. Were samples composited? | ___ | ___ |

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	<u>Yes</u>	<u>No</u>
4. Did sampling personnel utilize any preservative blanks?	___	___
5. Were any equipment blanks collected?	___	___
6. Were any duplicate samples collected?	___	___
7. Were any spiked samples utilized?	___	___
8. Check method used to collect split sample ___ Filled one large container and then transferred portions ___ Sequentially filled bottles		
9. Were chain of custody records completed for all samples?	___	___
10. Were all samples identified with appropriate tags?	___	___
11. Were sample I.D. tags filled out properly?	___	___
12. Did information on sample I.D. tags and Chemistry Field Data Log match?	___	___
13. Were samples kept in a secure place after collection?	___	___
14. Was Chemistry Field Data Log signed by sampling personnel?	___	___
15. Were amendments to the project plan documented (on the project plan itself, in a project logbook, elsewhere)?	___	___

Comments: _____

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Comments: _____

Laboratory Quality Control:

	<u>Yes</u>	<u>No</u>
1. Have approved sample holding times been observed?	___	___
2. Have replicate analyses been performed on at least one sample?	___	___
3. Have spike analyses been performed on at least one sample?	___	___
4. Have the quality control reporting forms been properly filled out?	___	___
5. Are the field QC samples "blind" to the lab technicians?	___	___
6. Are current instrument calibration curves used for all methods?	___	___
7. Did the spiking procedures follow acceptable protocols for quantity and concentration?	___	___
8. Are quality control charts used to track QC precision and accuracy?	___	___
9. Are QC charts kept up to date?	___	___
10. Is the precision of the data presented within acceptable limits?	___	___
11. Is the accuracy of the data presented within acceptable limits?	___	___
12. Are recent (one year or less) performance audit results available?	___	___

15.0 Quality Assurance Reports

The Laboratory and Divisional Quality Assurance Officers are responsible for preparing a quarterly internal quality assurance report. These reports are for internal use and are not submitted to DER. These reports include the following:

1. An assessment of data accuracy, precision, and method detection limits
2. Results of performance and systems audits
3. Significant quality assurance/quality control problems and the recommended solution
4. Outcome of any corrective action.

Quality assurance reports to DER for SWIM projects are made on a variable schedule based on the frequency of sampling since these are on-going monitoring projects. For weekly, biweekly, or monthly sampling schedules, QA reports are submitted semiannually. For bimonthly, quarterly or semiannual sampling schedules, the QA reports are submitted annually. The reports to DER are written by the Divisional Quality Assurance Officers, Laboratory Quality Assurance Officer and the Project Managers. The Project Manager is responsible for submitting the report to DER.

If no project audits are performed and no significant quality assurance/quality control problems occur for a specific project, a letter stating these facts will be sent to DER in lieu of the quality assurance report.

The quality assurance reports must include the following for performance audits:

1. Date of the audit
2. System tested
3. Persons performing/administering the audit
4. Parameters analyzed
5. Reported results
6. True values of the samples (if applicable)
7. If any deficiencies or failures occurred, a summary of the problem and the corrective action taken
8. Copies of documentation.

The quality assurance reports must include the following for systems audits:

1. Date of the audit
2. System tested
3. Who performed/administered the audit
4. Parameters analyzed

16.0 Resumes

The resumes for the key personnel are provided in this section.

WILLIAM C. DONOVAN
Supervising-Professional-Chemist

Area of Specialization: Laboratory management, soil chemistry and water quality analysis

Experience: South Florida Water Management District

1988 - Present - Supervising Professional-Chemist, Chemistry Laboratory division. Responsible for the supervision of the first shift of the laboratory including personnel, data review, sample analysis, instrumentation and QA solutions.

1986 - 1988 - Senior Water Use Engineer. Responsible for urban and agricultural water use conservation programs such as Xeriscape and drip-irrigation on sugarcane.

University of Florida - IFAS, Belle Glade Research/Education Center

1982 - 1986 - Sugarcane Extension Specialist: Responsible for the IFAS Belle Glade Soil Testing Lab Results, the development of a program on sugarcane production and functioning as a technical expert on sugarcane.

Ohio Agricultural Development and Research Center, Wooster, Ohio

1978 - 1982 - Research Associate. Determined the amount of ammonia volatilization from different sewage sludges under controlled conditions of temperature, soil type, soil moisture, and vegetative cover.

Ohio River Commission, Cincinnati, Ohio

1974 - 1975 - Assistant Planner - Responsible for determining water quality discharge sites in a three state area. Coordinated activities with the Army Core of Engineer and other state and federal agencies

Education: Ohio State University, Columbus, Ohio
Ph.D. Soil Science - Soil Chemistry, 1982
M.S. - Natural Resource - Resource Management, 1976
B.S. Biology/Zoology, 1970

Professional Affiliations: Soil Science Society of America
American Society of Agronomy

LESLIE W. TEETS

Senior Chemist

Area of Specialization: Laboratory quality assurance and atomic absorption spectroscopy

Experience: South Florida Water Management District

1990 - Present - Senior Chemist, chemistry Laboratory Division. Responsible for the QA project for the division

1989 - 1990 Laboratory Quality Assurance Officer, Chemistry Laboratory Division. Responsible for laboratory Quality Assurance program; cation and trace metal analyses, and field QC spike preparation and data compilation.

1987 - 1989 - Staff Chemist, Chemistry Laboratory Division. Responsible for the laboratory Quality Assurance program, cation and trace metal analyses, and field QC spike preparation.

1985 - 1987 - Chemist, Chemistry Laboratory Division. Responsible for the laboratory quality assurance program, cation and trace metal analyses.

1984 - 1985 - Laboratory Technician III, Water Chemistry Division. Responsible for cation and trace metal analysis and method development.

1981 - 1984 - Laboratory Technician I and II, Water Chemistry Division. Responsible for sample preparation, nutrient analyses, and physical parameters.

Education: B.S. Chemistry (ACS) - 1981
Stetson University, Deland, Florida

Professional Affiliations: American Chemical Society
Florida Society of Environmental Analysts
Association of Official Analytical Chemists

THOMAS D. FONTAINE, Ph.D.

Director, Water Quality Division

Area of Specialization: Water Quality and Ecological Modeling, Environmental Systems Analysis.

Experience: South Florida Water Management District:

1990 - Present: Director, Water Quality Division.
Responsible for Water Quality research and analysis and modeling.

1988-1989: NOAA-Great Lakes Environ. Research Laboratory: Program Leader, Coordinated Ecosystem Research, Environ. Systems Studies

1983: Computer Sci. Corp.-USEPA Great Lakes Nat. Program Office - Tech. Project Leader

University of Georgia, Savannah River Ecology Lab

1982-1983: Asst. Ecologist
1979-1982: Res. Assoc.

Education: Ph.D. Systems Ecology, Dept. Environmental Eng. Sciences, University of Florida, 1978;
M.S. Environ. Biology, Dept. Environmental Eng. Sciences, University of Florida, 1974;
B.A. Biology, University of Mississippi, 1972.

Professional Affiliations: Editorial Advisory Board, "The Handbook of Environmental Chemistry," Springer-Verlag.

NSF-NOAA Joint Committee on Global Ecosystem Dynamics.

Specialist Technical Group on Systems Analysis in Water Quality Management (IAWPRC)

Secretary-General, North American Chapter, International Society for Ecological Modeling.

GUY J. GERMAIN

Staff Environmental Scientist

Area of Specialization: Surface water quality monitoring and design of monitoring programs. Data analysis, and performing loading calculations.

Experience: South Florida Water Management District

1991 to present - Staff Environmental Scientist, Water Quality Division. Responsible for managing several water quality monitoring programs. Performing loading calculations for the WCA's. Data analysis, and Partial supervision of field technicians.

1989-1991, Staff Environmental Scientist, Lower East Coast Planning Division. Responsible for overseeing several projects and contracts that were part of the Everglades SWIM Program.

1982-1989, Environmentalist, Water Quality Division. Responsible for managing several water quality monitoring programs. Performing loading calculations for the WCA's. And data analysis.

1978-1982, Field Technician, Water Quality Division. Responsible for water quality monitoring and sample collection, maintenance of field equipment, stream gauging, and collection of flow charts from stage recorders, at the Okeechobee Environmental Research Center in Okeechobee.

Education: B.S.- Environmental Engineering, 1978.
Florida International University, Miami, Florida.

GREGORY J. SAWKA

Staff Environmental Scientist

Area of Specialization: Watershed monitoring evaluation, quality control and data interpretation, soil interpretations, soil mapping and spatial variability.

Experience: South Florida Water Management District

1989 - Present. Research Environmentalist, Water Quality Division. Perform water quality data interpretations, prepare technical reports and QA/QC documentation. Conduct water quality computer modeling.

Citrus County Planning and Zoning Department

1988 - 1989: Environmental Specialist/Planner. Responsible for preparing county ordinances and permit evaluation in areas of environmental concern including dredge and fill permits, wetland mitigation, and landfill siting.

Southeast Soil & Environmental Service, Inc., Gainesville, FL

1984 - 1988 Private Soil Consultant. Provide soil analysis, testing and interpretation involving land development, research projects, and environmental litigation.

University of Florida, Gainesville, FL

1986 - 1988: Research Soil Scientist. Served as a grant proposal member involving studies in seasonal water movement in soils and detailed soil mapping and interpretations.

1983 - 1986: Graduate Research Assistant. Evaluated Florida soils for on-site sewage disposal systems and water table drainage class analysis. Assist in soil training programs for FDHRS field personnel.

Missouri Department of Natural Resources, Calloway County, MO

1980 - 1983: Soil Scientist. Served as a member of Soil Conservation Service soil survey party. Duties include mapping and classifying soils, supervision and training, public relations, promotion and development of soil surveys and soil and other conservation projects.

Education: M.S. - Soil Science, 1986, University of Florida, Gainesville, FL
B.S. - Environmental Science, 1978, Southampton College, Southampton, NY
A.S. - Oceanographic Technology, 1974, Florida Institute of Technology, Jensen Beach, FL

GARTH W. REDFIELD, PH.D.

Director, Environmental Sciences Division

Area of Specialization: Limnology, Trophic Interactions

Experience: South Florida Water Management District

1990 to Present - Division Director, Environmental Sciences Division. Responsible for environmental research and analysis.

National Science Foundation, Ecology Program, Washington, D.C.

1989-1990 - Aquatic Ecologist and Research

1982-1990 - Associate Program Director.

North Carolina State University, Raleigh, NC.

1988-1989 - Dept. of Zoology, Visiting Associate Professor.

Silver Spring, Maryland

1982-1990 - Consulting Ecologist, unaffiliated.

George Mason University, Dept. of Biology, Fairfax, Virginia

1981-1982 - Adjunct Assistant Professor.

NUSAC Incorporated, Reston, Virginia

1979-1981 - Senior Ecologist.

University of California, Division of Environmental Sciences and Institute of Ecology, Davis, California

1979 - Postdoctoral Research Associate

1972-1978 - Laboratory, Teaching and Research Assistantships.

Ecological Research Associates, Davis, California

1977-1979 - Researcher and Consultant.

STEVEN M. DAVIS

Supervising Professional Environmental Scientist

Area of Specialization: Wetland ecology, plant ecology, wetland nutrient cycling, Everglades ecosystem management and restoration

Experience: South Florida Water Management District

1989 - 1990 - Supervising Professional Environmental Scientist, Environmental Sciences Division. (Acting Assistant Division Director, 1990). Responsible for supervision of environmental research programs on the Kissimmee River, Lake Okeechobee, Everglades Water Conservation Areas, and estuaries, co-chairman of the Everglades Symposium and senior editor of the proceedings of the symposium, and research on the long-term vegetation change in the Everglades.

1986 - 1989 - Senior Environmentalist, Environmental Sciences Division. Responsible for program design and contracts for ecological research on the Kissimmee River and Everglades Water Conservation Areas. Assistant leader of the team to restore Holeyland Everglades habitat, leader of the team that developed the floodplain habitat restoration plans for three Kissimmee River tributaries.

1982 - 1986 - Environmentalist 4, Environmental Sciences Division. Responsible for completion of 11 year research program on plant succession and nutrient retention in a Kissimmee River marsh and supervision and program design for research programs on Everglades plant ecology and nutrient cycling.

1977 - 1982 - Environmentalist 3, Environmental Sciences Division. Responsible for development of methodology to estimate annual production by Everglades macrophytes, development of methodology to determine nutrient impacts and uptake potentials of Everglades sawgrass and cattail communities, radiotracer experiments to determine phosphorus distribution in Everglades ecosystem components.

1970 - 1977 - Biologist 2, Environmental Sciences Division. Responsible for trammel net study in St. Johns River, two year study on St. Johns River floodplain vegetation, design and initiation of long-term study Kissimmee River marsh, and design and initiation of long-term study of nutrient cycling by Everglades vegetation.

Education: University of Georgia, Athens, GA
M.S. Ecology, 1970

University of Illinois, Champaign-Urbana, IL
B.S. Zoology, 1966

NICHOLAS G. AUMEN, Ph.D.
Supervising Professional Environmental Scientist

Area of Specialization: Aquatic Microbial Ecology, Trophic-dynamic Interactions, Solute Dynamics in Aquatic Ecosystems, Water Quality Monitoring and Assessment, Surface Water and Groundwater Pollution

Experience: South Florida Water Management District -Oversee Lake Okeechobee ecosystem and Estuarine research programs. (1991 to Present)

University of Mississippi, Dept. of Biology, University, Mississippi,
1985-1991 - Assistant Professor

U.S. Forest Service, Mt. Hood National Forest, Oregon
1986, 1987 (summers) - Consulting Scientist
Conducted research on nutrient dynamics in streams.

Water Quality Science, Inc.
1986-1987 - Consulting Scientist. Evaluated effectiveness of bacterial product designed to reduce nutrient and organic loading in aquaculture systems.

NSF Research Cruise C8608, Little Grand Bank, Bahama Islands
1986 - Scientific Crew Member.

NSF Research Cruise C8512, Little Grand Bank, Bahama Islands
1985 - Associate Chief Scientist.

Oregon State University, Oregon
1984 - Post-doctoral Research Associate.

University of Pittsburgh Pymatuning Laboratory of Ecology, Linsville
Pennsylvania
1980 - Research Fellowship.
Pensacola Junior College, Pensacola, Florida

1979-1980 - Instructor, general zoology.

University of West Florida, Dept. of Biology, Pensacola, Florida
1976-1979 - Graduate research and teaching assistant.

Education: Oregon State University, Corvallis, Oregon - Ph.D., Microbiology,
1984
University of West Florida, Pensacola, Florida, M.S., Biology, 1979,
B.S., Biology, 1976

Okaloosa-Walton Junior College, Niceville, Florida, A.A., Biology,
1974

NANCY H. URBAN

Staff Environmental Scientist

Area of Specialization: Wetlands Ecology, Vegetation Dynamics

Experience: *South Florida Water Management District*

1987 to Present, Staff Environmental Scientist, Environmental Sciences Quality Assurance Officer, Environmental Sciences Division. Responsible for managing projects for nutrient, vegetation and invertebrate studies in the Water Conservation Areas, marsh management technique study in Kissimmee River Floodplain.

1981 - 1987, Environmental Research Technician, Environmental Sciences Division. Assisted in wetland field studies; litter decomposition, radiotracing P32, leaf growth and mortality, nutrient fluxes in root systems, invertebrate, and plant succession.

Connell, Metcalf and Eddy, Inc., Coral Gables, Florida

1980 - Technician, Environmental Sciences Division. Environmental Impact Studies, field studies; benthic, seagrass, crocodile, vegetation and water quality monitoring.

South Florida Research Center, Everglades National Park

1978 - 1980 - Technician, Plant Ecology. Vegetation analyses of various community types, vegetation mapping, aerial photo interpretation, plant identification.

Education: 1978, B.S. Biology
University of Miami, Coral Gables, Florida

JEFFRY W. HERR

Staff Hydrogeologist

Area of Specialization: Groundwater quality monitoring and sampling.

Experience: South Florida Water Management District

1990 - present - Staff Hydrogeologist, Hydrogeology Quality Assurance Officer, Hydrogeology Division. Responsible for management of the Ambient Ground Water Quality Monitoring Program, development of project goals, supervision of field sampling personnel, collection and interpretation of groundwater quality data, and writing technical reports on research findings.

1989 - 1990 - Research Hydrogeologist, Water Quality Division. Responsible for the supervision of field sampling personnel, collection and interpretation of groundwater quality data and writing technical reports on research findings.

1985 - 1989 - Hydrogeologist, Water Quality Division. Responsible for the collection and interpretation of groundwater quality data and writing technical reports on research findings.

1983 - 1985 - Hydrogeologist, Groundwater Division. Responsible for the collection and interpretation of groundwater quality data and developing methodologies and procedures for groundwater quality monitoring.

Education: Florida Atlantic University, Boca Raton, FL
B.S. Geology, 1983

Professional Affiliations: National Water Well Association
Florida Academy of Sciences

Certification: Professional Geologist, State of Florida